Agenda
Planning Board Development Regulations Subcommittee
August 7, 2020

Agenda Item #3A
Study Items

New review of proposed amendments to Site Plan Regulations relative to Lighting

g. Enforcement

The Planning Board may require routine inspections to insure compliance with the Design Standards & Construction & Post Construction sections of these regulations. Such inspections shall be performed by a designated agent with appropriate certifications at reasonable times to the landowner. If permission to inspect is denied by the landowner, the designated agent shall secure an administrative inspection warrant from the district or superior court under RSA 595-B.

When the responsible party fails to implement the O&M plan, including, where applicable, the SMP, as determined by the Code Enforcement Officer or City Council, the municipality is authorized to assume responsibility for their implementation and to secure reimbursement for associated expenses from the responsible party, including if necessary, placing a lien on the subject property.

I. WAIVERS

An applicant may request a waiver from any of the provisions in this Section. For such waiver requests, in addition to the standards set forth in Section 7.1 of these Regulations:

(a) The Board shall consider whether there exist adequate reasons to believe that the goals and purposes of this section, including those set forth in Section 6.6(A) above, will be achieved, notwithstanding such waiver

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(b) In the case of a waiver request from Section G.2, the Board shall determine whether the Stormwater Management Plan for the redevelopment project attains achievement of the goals of this section to the maximum practicable extent, as determined by the Board with the assistance of the Reviewing Engineer. The Board shall also consider the stormwater management benefits of redevelopment as compared to development of raw land.

Section 6.7. – Lighting

A. Purpose

The purpose of this section is to guide property owners and applicants in appropriately lighting their non-residential and multi-family development proposals.

New lighting technologies have produced lights that are extremely powerful and thus need to be installed sensibly so that they do not create problems of excessive glare, light trespass, skyglow, and higher energy use. Outdoor lighting along roadways, walkways, parking lots, and other public areas shall be designed and located with consideration to fixture and lamp type, mounting height, spacing, and distribution of light in order to: assure adequate illumination for the safety and security of drivers, pedestrians, bicyclists, and other passersby; avoid adverse impacts to adjacent properties and on wildlife habitat; assure that light pollution does not limit the ability of citizens to enjoy the nighttime sky; and minimize the unnecessary use of electricity.

B. General Requirements

Proposed lighting installations may be approved only if the Board finds that they are designed to prevent light trespass onto adjacent properties or streets, minimize light directed skyward, and do not result in excessive lighting levels.

Outdoor lighting shall be located, mounted, aimed, and shielded in such a way that adjacent uses are suitably protected from light trespass. Such lighting shall not interfere with traffic on nearby highways. The standards and guidelines contained in the most current edition of the *Illuminating Engineering Society of North America (IESNA) Lighting Handbook* shall be utilized to determine the appropriateness of exterior lighting levels and conformity with these Regulations.

All light fixtures, including fixtures mounted inside buildings or structures, shall be located, mounted, aimed, and shielded so as to minimize glare perceptible to drivers, pedestrians, bicyclists, and other passersby within adjacent streets or rights-of-way.

In addition to these general standards, the following shall also apply:

1. Lighting installations shall be designed to provide the minimum illumination necessary to facilitate the use of the site. Except as otherwise stated in the special provisions of this section or unless approved by the Board, lighting levels shall not exceed the minimum level of illumination recommended by the IESNA for the proposed use and level of activity.

2. Light fixtures shall be located, mounted, aimed, and shielded so as to not cause light trespass upon adjacent properties or onto streets or rights-of-way in excess of the following levels: The light intensity at adjoining streets or commercial property boundaries shall not exceed 0.5 foot-candles at grade level, and the light intensity at adjoining residential property boundaries shall not exceed 0.1 foot-candles at grade level.

3. Lighting installations shall utilize fully-shielded fixtures, as defined herein, or full cut-off fixtures, as defined by the IESNA, so as to produce no light above a horizontal plane through the lowest direct light-emitting part of the fixture.

4. Lighting installations shall include timers, dimmers, sensors, and/or other energy-saving technologies to reduce overall energy consumption. Non-essential lighting shall be turned off or reduced after normal business hours, leaving only necessary lighting for security purposes. (Non-essential lighting includes, but may not be limited to, display, aesthetic, parking, and/or sign lighting as determined by the Board.)

5~~e~~. ~~The mounting height of all light fixtures shall be equal to or less than the value of (3+D/3), where 'D' is the distance in feet to the nearest property boundary.~~ The maximum mounting height of the light fixture shall not exceed fifteen (15) feet in residential zoning

districts or twenty (20) feet in commercial, institutional, or mixed zoning districts.

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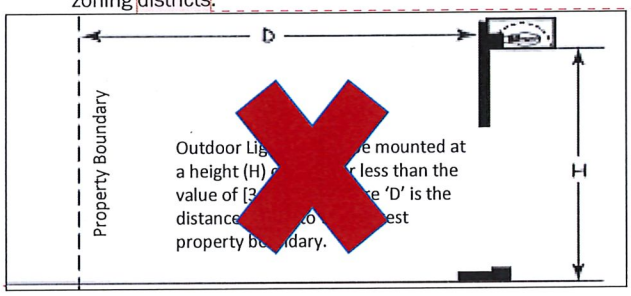

6.~~F.~~ Lighting installations used to illuminate areas such as streets, walkways, or parking lots shall utilize energy-efficient lighting such as LED (light-emitting diodes), low-pressure sodium, high-pressure sodium, metal halide lamps, or equivalent technology in terms of luminaire efficacy as measured in lumens/watt. Mercury vapor lamps shall not be used due to their inefficiency, high operating costs, and toxic mercury content.

Technological advances in outdoor lighting may allow for options not otherwise considered in these Regulations. The use of new technologies, especially those that have energy-saving properties, is encouraged. Applications that use new technologies and follow the purpose and intent of these Regulations will be considered and evaluated for approval.

7. Floodlights or spotlights shall be mounted above the object or area targeted for lighting and shall be shielded and aimed no higher than 45 degrees above straight down (half-way between straight down and the horizontal plane).

8. Uplighting is prohibited, except as allowed for the Lighting of Building Façades and Landscaping, as set forth in Paragraph 5 below.

9. In order to minimize the risk of disability glare, harm to human and ecological health, and to promote visual access to dark skies, all outdoor lighting shall have a Color Correlated Temperature (CCT) of 2700 Kelvin (K) or less (warmer light), unless a compelling need for a higher CCT (cooler light) can be demonstrated based on supporting evidence. Luminaires may prove qualification by being listed as Dark Sky Friendly by the International Dark Sky Association.

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C. Lighting of Parking Lots, Passive Vehicular Storage Areas, and Exterior Display/Sales Areas

In addition to the General Requirements listed in Paragraph 2 above, the following standards shall apply:

1.. Areas designated as parking lots, passive vehicular storage areas, or exterior display/sales areas shall be illuminated so that the average horizontal illuminance at grade level is no more than 5.0 foot-candles. The uniformity ratio (ratio of average to minimum illuminance) shall be no greater than 4:1. The average and minimum shall be computed for only that area designated as parking lots, passive vehicular storage areas, and exterior display/sales areas.

2. The above standards shall also apply to the top and/or unenclosed levels of any parking structure.

D. Lighting of Gasoline Station/Convenience Store Aprons and Canopies

In addition to the General Requirements listed in Paragraph 2 above, the following standards shall apply:

1. Areas on the apron used for parking or vehicle storage away from the gasoline pump islands, as defined by the extent of the canopy, shall be illuminated in accordance with the requirements for parking areas set forth in Paragraph 3 above. If no gasoline pumps are provided, the entire apron shall be treated as any other parking area.

2. Areas around the pump islands and under the canopies shall be illuminated so that the minimum horizontal illuminance at grade level is at least 1.0 foot-candle and no more than 5.0 foot-candles. The uniformity ratio (ratio of average to minimum illuminance) shall be no greater than 4:1, which yields an average illumination level of no more than 20.0 foot-candles.

3. Light fixtures mounted on canopies shall be recessed, so that the lens cover either is recessed or flush with the bottom surface (ceiling) of the canopy, and/or is shielded by the fixture or the edge of the canopy. The light shall be restrained to no more than 85 degrees from vertical.

4. As an alternative (or supplement) to recessed ceiling lights, indirect lighting may be used whereby light is beamed upward and then reflected down from the underside of the canopy. In this case, fixtures must be shielded so that direct light is focused exclusively on the underside of the canopy.

5. Lights shall not be mounted on the top or fascias of the canopy, and the sides or fascias of the canopy shall not be illuminated.

The above photographs illustrate the impact of glare on a lighting installation. The left photo has high-glare, non-recessed fixtures under the canopy. Note how bright the lights themselves are and how dark the pump area is. The right photo shows the same gas station canopy with full-cutoff, recessed fixtures. Note how the light is directed effectively toward the gas pumps.Images from http://www.skyandtelescope.com

E. Lighting of Building Façades and Landscaping

When approved by the Board, building façades of a dark color (such as brick or dark paint), façades of symbolic or historic structures, and/or landscaping features when required for safety, may be illuminated according to the following guidelines:

1. The maximum illumination on any vertical surface or angular roof surface shall not exceed 5.0 foot-candles.

2. Light fixtures shall be carefully located, aimed, and shielded so that light is directed only onto the building façade or the object or area targeted for lighting. Light fixtures shall not be directed toward adjacent properties, streets or roads, nor skyward.

3. Light fixtures mounted on the building and designed to "wash" the façade with light are preferred.

4. To the extent practicable, light fixtures shall be directed downward, below the horizontal plane.

F. Lighting of Walkways/Bikeways and Parks

5. Areas within parks or along walkways and bikeways to be illuminated shall not exceed an average level of 1.0 foot-candle at grade level.

6. Light fixtures for walkways and bikeways and within parks shall be mounted no more than 15 feet above grade and shall be designed to direct light downward.

G. Lighting of Signs

1. Fixtures used to illuminate signs shall be located, aimed, and shielded so as to minimize glare perceptible to drivers, pedestrians, bicyclists, and other passersby within adjacent streets or rights-of-way.

2. Floodlights or spotlights used for external lighting of signs shall be mounted above the sign targeted for lighting. Illumination shall be properly focused upon and confined to the area of the sign.

3. Internally lit signs shall be designed with an opaque background so that only the lettering, symbols, or designs shall appear to be lighted in order to minimize glare visible from adjacent streets or rights-of-way.

4. Moving, fluttering, blinking, or flashing lights shall not be permitted for the illumination of signs in order to avoid undue distraction, confusion, or hazard to the surrounding area or vehicular traffic, except as allowed in Section 608 of the Zoning Ordinance.

H. Pre-existing Outdoor Lighting

1. Any light fixture that replaces a pre-existing, non-conforming light fixture, or any light fixture that is relocated, shall meet the standards of these Regulations, unless otherwise approved by the Board.

I. Exemptions

1. Light fixtures used for roadway illumination may be installed at a maximum height of 25 feet and may be positioned at that height up to the edge of any bordering property.

2. Notwithstanding the requirements of this Section, the Board may approve architectural or decorative light fixtures, which are not fully shielded, if such fixtures are designed to minimize glare; direct illumination downward; are not mounted at a height greater than 15 feet; and have an initial output of no more than 1,800 initial lumens (with 1,700 lumens being the typical output of a 100-watt incandescent bulb). In approving such fixtures, the Board may require that the light source be screened by a refractive lens or translucent globe, so that the light source is not directly visible.

3. Hazard-warning lights required by federal regulatory agencies, such as the Federal Aviation Administration (FAA) or Federal Communications Commission (FCC) shall be exempt from these Regulations. In addition, temporary lighting required by police, fire, public authorities, or other emergency services shall be exempt from these Regulations.

4. Seasonal holiday lighting and illumination of the American and state flags shall be exempt from these Regulations, provided that such lighting does not produce glare on roadways or neighboring properties.

~~G. Multifamily Recreational Facilities~~

~~Site plans for multifamily structures shall make adequate provision for the on site recreational needs of the residents of the proposed development. The plan shall be designed to minimize the likelihood that public safety will be endangered by the extensive use of internal roads and parking areas for recreation.~~

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Proposed Addition to City of Lebanon Site Plan Regulations

RE: Color Temperature of Outdoor Lighting

Proposed by City Councilor Clifton Below

6/19/20

I'd like to propose that the City's Site Plan Regulations be amended to require outdoor lighting to have a Color Correlated Temperature of 3000 K (Kelvin – a scale for measuring the color balance of light spectrum from warm to cool (yellow/red to blue). Incandescent lighting is mostly 2700 K. High Pressure Sodium, like most of the City's streetlights, mostly ranges from 1900 K to 2300 K, but is also available in 2700 K. Daylight starts and ends as warm or warmer than incandescent at dawn and dusk (2000 to 2700 K) and moves past 3000 K within the first hour of daylight up to 5500 K at noon on a sunny day and even cooler when it is overcast, around 6500 K. Today 3000 K and warmer LED and Metal Halide luminaires are widely available.

The American Medical Association has an adopted policy calling for all outdoor lighting to be 3000 K CCT or warmer in color temperature to protect human and ecological health. (The blue wavelengths more prominent in light sources cooler than 3000 K suppresses melatonin production, a hormone that serves as a biological signal for sleep and rest in humans and other species, which is undesirable after dark. Bluer LEDs typically cause more disability glare than warmer LEDs after dark and also cause increased pupil dilation, slowing adjustment (night vision) to seeing in lower illumination areas.) The AMA's background report can be found here: https://www.ama-assn.org/sites/ama-assn.org/files/corp/media-browser/public/about-ama/councils/Council%20Reports/council-on-science-public-health/a16-csaph2.pdf.

The International Dark Sky Association also calls for outdoor lighting to be 3000 K CCT or warmer to be considered dark sky friendly. Both of these supporting policy statements are reference in City of Lebanon Administrative Policy, ADM-109 *"Lighting-Public Ways/Places/Parking Facilities"* adopted 10/18/18 by the City Manager. Although it only applies to City provided or paid for outdoor lighting, it specifies:

"4.2 Characteristics of Outdoor Lighting

In general, the City will seek to convert existing outdoor lighting and limit new installations to luminaires that are consistent with the AMA guidelines on avoidance of harm from outdoor community lighting and the International Dark Sky Association list of approved dark sky friendly fixtures, including, in particular use of lamps with:

- full horizontal cut-off consistent with the City's Site Plan Regulations for outdoor lighting;
- sharp cut off behind the fixture where light trespass onto private property may occur and not be desired;
- a Correlated Color Temperature (CCT) of 3000°K or less;
- a color rendering index of 70 or greater.

The DPW Director may allow exceptions to this policy where needed."

That policy is available at: https://lebanonnh.gov/DocumentCenter/View/8431/2018-10-18-Approved-ADM-109-Lighting-Public-Places-Policy.

It is worth noting that NH Law specifically includes a Dark Sky Policy that authorizes and encourages municipalities to regulate outdoor lighting to promote dark sky friendly lighting at RSA 9-E:3: http://www.gencourt.state.nh.us/rsa/html/I/9-E/9-E-3.htm.

The specific suggested amendment would be to Section 6.7, Lighting, ¶2, General Regulations, by adding a new subparagraph i, after the last subparagraph h (on p. 49):

> i. [In order to minimize the risk of disability glare, harm to human and ecological health, and to promote visual access to dark skies,] all outdoor lighting shall have a Color Correlated Temperature (CCT) of 3000 Kelvin (K) or less (warmer), [unless a compelling need for a cooler temperature can be demonstrated based on supporting evidence]. Luminaires with a CCT of 2700 K or warmer are preferable. Luminaires may prove qualification by being listed as Dark Sky Friendly by the International Dark Sky Association.

The core of the proposal is the highlighted language. The other parts are optional.

I'd also like to note that on behalf of the City of Lebanon I provided written testimony in Liberty Utilities' DE 19-064 distribution rate case calling for Liberty to offer all of their outdoor LED lighting options in 3000K or warmer color temperature. As there was no rebuttal testimony, this provision was incorporated into the settlement of the case and includes a provision that 3000 K fixtures will be provided by default if the customer doesn't specify that they want a 4000 K luminaire. These new provisions should go into effect on 7/1/20. My testimony can be found here, the most relevant portions on pp. 9-10: https://www.puc.nh.gov/Regulatory/Docketbk/2019/19-064/TESTIMONY/19-064_2019-12-09_COL_TESTIMONY_BELOW.PDF and supporting exhibits (D – F concerning this issue, pp. 28-41) are found here: https://www.puc.nh.gov/Regulatory/Docketbk/2019/19-064/TESTIMONY/19-064_2019-12-10_COL_ATT_TESTIMONY_FILED_12-09-19.PDF.

Here is an example of site lighting (recently installed) in Lebanon (lower right, U-Haul facility from roof of One Court Street) that would violate this (and other provisions) of the regulations, if they applied, and you can see how cool LED lighting (probably 4000 or 5000 K) contrasts with other, mostly much warmer, outdoor lighting:

REPORT OF THE COUNCIL ON SCIENCE AND PUBLIC HEALTH

CSAPH Report 2-A-16

Subject: Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting

Presented by: Louis J. Kraus, MD, Chair

Referred to: Reference Committee E
(Theodore Zanker, MD, Chair)

INTRODUCTION

With the advent of highly efficient and bright light emitting diode (LED) lighting, strong economic arguments exist to overhaul the street lighting of U.S. roadways.[1-3] Valid and compelling reasons driving the conversion from conventional lighting include the inherent energy efficiency and longer lamp life of LED lighting, leading to savings in energy use and reduced operating costs, including taxes and maintenance, as well as lower air pollution burden from reduced reliance on fossil-based carbon fuels.

Not all LED light is optimal, however, when used as street lighting. Improper design of the lighting fixture can result in glare, creating a road hazard condition.[4,5] LED lighting also is available in various color correlated temperatures. Many early designs of white LED lighting generated a color spectrum with excessive blue wavelength. This feature further contributes to disability glare, i.e., visual impairment due to stray light, as blue wavelengths are associated with more scattering in the human eye, and sufficiently intense blue spectrum damages retinas.[6,7] The excessive blue spectrum also is environmentally disruptive for many nocturnal species. Accordingly, significant human and environmental concerns are associated with short wavelength (blue) LED emission. Currently, approximately 10% of existing U.S. street lighting has been converted to solid state LED technology, with efforts underway to accelerate this conversion. The Council is undertaking this report to assist in advising communities on selecting among LED lighting options in order to minimize potentially harmful human health and environmental effects.

METHODS

English language reports published between 2005 and 2016 were selected from a search of the PubMed and Google Scholar databases using the MeSH terms "light," "lighting methods," "color," "photic stimulation," and "adverse effects," in combination with "circadian rhythm/physiology/radiation effects," "radiation dosage/effects," "sleep/physiology," "ecosystem," "environment," and "environmental monitoring." Additional searches using the text terms "LED" and "community," "street," and "roadway lighting" were conducted. Additional information and perspective were supplied by recognized experts in the field.

ADVANTAGES AND DISADVANTAGES OF LED STREET LIGHTS

The main reason for converting to LED street lighting is energy efficiency; LED lighting can reduce energy consumption by up to 50% compared with conventional high pressure sodium (HPS)

lighting. LED lighting has no warm up requirement with a rapid "turn on and off" at full intensity. In the event of a power outage, LED lights can turn on instantly when power is restored, as opposed to sodium-based lighting requiring prolonged warm up periods. LED lighting also has the inherent capability to be dimmed or tuned, so that during off peak usage times (e.g., 1 to 5 AM), further energy savings can be achieved by reducing illumination levels. LED lighting also has a much longer lifetime (15 to 20 years, or 50,000 hours), reducing maintenance costs by decreasing the frequency of fixture or bulb replacement. That lifespan exceeds that of conventional HPS lighting by 2-4 times. Also, LED lighting has no mercury or lead, and does not release any toxic substances if damaged, unlike mercury or HPS lighting. The light output is very consistent across cold or warm temperature gradients. LED lights also do not require any internal reflectors or glass covers, allowing higher efficiency as well, if designed properly.[8,9]

Despite the benefits of LED lighting, some potential disadvantages are apparent. The initial cost is higher than conventional lighting; several years of energy savings may be required to recoup that initial expense.[10] The spectral characteristics of LED lighting also can be problematic. LED lighting is inherently narrow bandwidth, with "white" being obtained by adding phosphor coating layers to a high energy (such as blue) LED. These phosphor layers can wear with time leading to a higher spectral response than was designed or intended. Manufacturers address this problem with more resistant coatings, blocking filters, or use of lower color temperature LEDs. With proper design, higher spectral responses can be minimized. LED lighting does not tend to abruptly "burn out," rather it dims slowly over many years. An LED fixture generally needs to be replaced after it has dimmed by 30% from initial specifications, usually after about 15 to 20 years.[1,11]

Depending on the design, a large amount blue light is emitted from some LEDs that appear white to the naked eye. The excess blue and green emissions from some LEDs lead to increased light pollution, as these wavelengths scatter more within the eye and have detrimental environmental and glare effects. LED's light emissions are characterized by their correlated color temperature (CCT) index.[12,13] The first generation of LED outdoor lighting and units that are still widely being installed are "4000K" LED units. This nomenclature (Kelvin scale) reflects the equivalent color of a heated metal object to that temperature. The LEDs are cool to the touch and the nomenclature has nothing to do with the operating temperature of the LED itself. By comparison, the CCT associated with daylight light levels is equivalent to 6500K, and high pressure sodium lighting (the current standard) has a CCT of 2100K. Twenty-nine percent of the spectrum of 4000K LED lighting is emitted as blue light, which the human eye perceives as a harsh white color. Due to the point-source nature of LED lighting, studies have shown that this intense blue point source leads to discomfort and disability glare.[14]

More recently engineered LED lighting is now available at 3000K or lower. At 3000K, the human eye still perceives the light as "white," but it is slightly warmer in tone, and has about 21% of its emission in the blue-appearing part of the spectrum. This emission is still very blue for the nighttime environment, but is a significant improvement over the 4000K lighting because it reduces discomfort and disability glare. Because of different coatings, the energy efficiency of 3000K lighting is only 3% less than 4000K, but the light is more pleasing to humans and has less of an impact on wildlife.

Glare

Disability glare is defined by the Department of Transportation (DOT) as the following:

> "Disability glare occurs when the introduction of stray light into the eye reduces the ability to resolve spatial detail. It is an objective impairment in visual performance."

Classic models of this type of glare attribute the deleterious effects to intraocular light scatter in the eye. Scattering produces a veiling luminance over the retina, which effectively reduces the contrast of stimulus images formed on the retina. The disabling effect of the veiling luminance has serious implications for nighttime driving visibility.[15]

Although LED lighting is cost efficient and inherently directional, it paradoxically can lead to worse glare than conventional lighting. This glare can be greatly minimized by proper lighting design and engineering. Glare can be magnified by improper color temperature of the LED, such as blue-rich LED lighting. LEDs are very intense point sources that cause vision discomfort when viewed by the human eye, especially by older drivers. This effect is magnified by higher color temperature LEDs, because blue light scatters more within the human eye, leading to increased disability glare.[16]

In addition to disability glare and its impact on drivers, many residents are unhappy with bright LED lights. In many localities where 4000K and higher lighting has been installed, community complaints of glare and a "prison atmosphere" by the high intensity blue-rich lighting are common. Residents in Seattle, WA have demanded shielding, complaining they need heavy drapes to be comfortable in their own homes at night.[17] Residents in Davis, CA demanded and succeeded in getting a complete replacement of the originally installed 4000K LED lights with the 3000K version throughout the town at great expense.[18] In Cambridge, MA, 4000K lighting with dimming controls was installed to mitigate the harsh blue-rich lighting late at night. Even in places with a high level of ambient nighttime lighting, such as Queens in New York City, many complaints were made about the harshness and glare from 4000K lighting.[19] In contrast, 3000K lighting has been much better received by citizens in general.

Unshielded LED Lighting

Unshielded LED lighting causes significant discomfort from glare. A French government report published in 2013 stated that due to the point source nature of LED lighting, the luminance level of unshielded LED lighting is sufficiently high to cause visual discomfort regardless of the position, as long as it is in the field of vision. As the emission surfaces of LEDs are highly concentrated point sources, the luminance of each individual source easily exceeds the level of visual discomfort, in some cases by a factor of 1000.[17]

Discomfort and disability glare can decrease visual acuity, decreasing safety and creating a road hazard. Various testing measures have been devised to determine and quantify the level of glare and vision impairment by poorly designed LED lighting.[20] Lighting installations are typically tested by measuring foot-candles per square meter on the ground. This is useful for determining the efficiency and evenness of lighting installations. This method, however, does not take into account the human biological response to the point source. It is well known that unshielded light sources cause pupillary constriction, leading to worse nighttime vision between lighting fixtures and causing a "veil of illuminance" beyond the lighting fixture. This leads to worse vision than if the light never existed at all, defeating the purpose of the lighting fixture. Ideally LED lighting installations should be tested in real life scenarios with effects on visual acuity evaluated in order to ascertain the best designs for public safety.

Proper Shielding

With any LED lighting, proper attention should be paid to the design and engineering features. LED lighting is inherently a bright point source and can cause eye fatigue and disability glare if it is allowed to directly shine into human eyes from roadway lighting. This is mitigated by proper

design, shielding and installation ensuring that no light shines above 80 degrees from the horizontal. Proper shielding also should be used to prevent light trespass into homes alongside the road, a common cause of citizen complaints. Unlike current HPS street lighting, LEDs have the ability to be controlled electronically and dimmed from a central location. Providing this additional control increases the installation cost, but may be worthwhile because it increases long term energy savings and minimizes detrimental human and environmental lighting effects. In environmentally sensitive or rural areas where wildlife can be especially affected (e.g., near national parks or bio-rich zones where nocturnal animals need such protection), strong consideration should be made for lower emission LEDs (e.g., 3000K or lower lighting with effective shielding). Strong consideration also should be given to the use of filters to block blue wavelengths (as used in Hawaii), or to the use of inherent amber LEDs, such as those deployed in Quebec. Blue light scatters more widely (the reason the daytime sky is "blue"), and unshielded blue-rich lighting that travels along the horizontal plane increases glare and dramatically increases the nighttime sky glow caused by excessive light pollution.

POTENTIAL HEALTH EFFECTS OF "WHITE" LED STREET LIGHTING

Much has been learned over the past decade about the potential adverse health effects of electric light exposure, particularly at night.[21-25] The core concern is disruption of circadian rhythmicity. With waning ambient light, and in the absence of electric lighting, humans begin the transition to nighttime physiology at about dusk; melatonin blood concentrations rise, body temperature drops, sleepiness grows, and hunger abates, along with several other responses.

A number of controlled laboratory studies have shown delays in the normal transition to nighttime physiology from evening exposure to tablet computer screens, backlit e-readers, and room light typical of residential settings.[26-28] These effects are wavelength and intensity dependent, implicating bright, short wavelength (blue) electric light sources as disrupting transition. These effects are not seen with dimmer, longer wavelength light (as from wood fires or low wattage incandescent bulbs). In human studies, a short-term detriment in sleep quality has been observed after exposure to short wavelength light before bedtime. Although data are still emerging, some evidence supports a long-term increase in the risk for cancer, diabetes, cardiovascular disease and obesity from chronic sleep disruption or shiftwork and associated with exposure to brighter light sources in the evening or night.[25,29]

Electric lights differ in terms of their circadian impact.[30] Understanding the neuroscience of circadian light perception can help optimize the design of electric lighting to minimize circadian disruption and improve visual effectiveness. White LED streetlights are currently being marketed to cities and towns throughout the country in the name of energy efficiency and long term cost savings, but such lights have a spectrum containing a strong spike at the wavelength that most effectively suppresses melatonin during the night. It is estimated that a "white" LED lamp is at least 5 times more powerful in influencing circadian physiology than a high pressure sodium light based on melatonin suppression.[31] Recent large surveys found that brighter residential nighttime lighting is associated with reduced sleep time, dissatisfaction with sleep quality, nighttime awakenings, excessive sleepiness, impaired daytime functioning, and obesity.[29,32] Thus, white LED street lighting patterns also could contribute to the risk of chronic disease in the populations of cities in which they have been installed. Measurements at street level from white LED street lamps are needed to more accurately assess the potential circadian impact of evening/nighttime exposure to these lights.

ENVIRONMENTAL EFFECTS OF LED LIGHTING

The detrimental effects of inefficient lighting are not limited to humans; 60% of animals are nocturnal and are potentially adversely affected by exposure to nighttime electrical lighting. Many birds navigate by the moon and star reflections at night; excessive nighttime lighting can lead to reflections on glass high rise towers and other objects, leading to confusion, collisions and death.[33] Many insects need a dark environment to procreate, the most obvious example being lightning bugs that cannot "see" each other when light pollution is pronounced. Other environmentally beneficial insects are attracted to blue-rich lighting, circling under them until they are exhausted and die.[34,35] Unshielded lighting on beach areas has led to a massive drop in turtle populations as hatchlings are disoriented by electrical light and sky glow, preventing them from reaching the water safely.[35-37] Excessive outdoor lighting diverts the hatchlings inland to their demise. Even bridge lighting that is "too blue" has been shown to inhibit upstream migration of certain fish species such as salmon returning to spawn. One such overly lit bridge in Washington State now is shut off during salmon spawning season.

Recognizing the detrimental effects of light pollution on nocturnal species, U.S. national parks have adopted best lighting practices and now require minimal and shielded lighting. Light pollution along the borders of national parks leads to detrimental effects on the local bio-environment. For example, the glow of Miami, FL extends throughout the Everglades National Park. Proper shielding and proper color temperature of the lighting installations can greatly minimize these types of harmful effects on our environment.

CONCLUSION

Current AMA Policy supports efforts to reduce light pollution. Specific to street lighting, Policy H-135.932 supports the implementation of technologies to reduce glare from roadway lighting. Thus, the Council recommends that communities considering conversion to energy efficient LED street lighting use lower CCT lights that will minimize potential health and environmental effects. The Council previously reviewed the adverse health effects of nighttime lighting, and concluded that pervasive use of nighttime lighting disrupts various biological processes, creating potentially harmful health effects related to disability glare and sleep disturbance.[25]

RECOMMENDATIONS

The Council on Science and Public Health recommends that the following statements be adopted, and the remainder of the report filed.

1. That our American Medical Association (AMA) support the proper conversion to community-based Light Emitting Diode (LED) lighting, which reduces energy consumption and decreases the use of fossil fuels. (New HOD Policy)

2. That our AMA encourage minimizing and controlling blue-rich environmental lighting by using the lowest emission of blue light possible to reduce glare. (New HOD Policy)

3. That our AMA encourage the use of 3000K or lower lighting for outdoor installations such as roadways. All LED lighting should be properly shielded to minimize glare and detrimental human and environmental effects, and consideration should be given to utilize the ability of LED lighting to be dimmed for off-peak time periods. (New HOD Policy)

Fiscal Note: Less than $500

REFERENCES

1. Municipal Solid State Street Lighting Consortium. http://www1.eere.energy.gov/buildings/ssl/consortium.html. Accessed April 4, 2016.

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THE CONVERSATION
Academic rigor, journalistic flair

American Medical Association warns of health and safety problems from 'white' LED streetlights

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New LED-based streetlights are whiter than traditional ones and contain more blue light, which can disrupt people's circadian rhythms. meltedplastic/flickr, CC BY-NC-ND

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The American Medical Association (AMA) has just adopted an official policy statement about street lighting: cool it and dim it.

The statement, adopted unanimously at the AMA's annual meeting in Chicago on June 14, comes in response to the rise of new LED street lighting sweeping the country. An AMA committee issued guidelines on how communities can choose LED streetlights to "minimize potential harmful human health and environmental effects."

Municipalities are replacing existing streetlights with efficient and long-lasting LEDs to save money on energy and maintenance. Although the streetlights are delivering these benefits, the AMA's stance reflects how important proper design of new technologies is and the close connection between light and human health.

The AMA's statement recommends that outdoor lighting at night, particularly street lighting, should have a color temperature of no greater than 3000 Kelvin (K). Color temperature (CT) is a measure of the spectral content of light from a source; how much blue, green, yellow and red there is in it. A higher CT rating generally means greater blue content, and the whiter the light appears.

A white LED at CT 4000K or 5000K contains a high level of short-wavelength blue light; this has been the choice for a number of cities that have recently retrofitted their street lighting such as Seattle

and New York.

But in the wake of these installations have been complaints about the harshness of these lights. An extreme example is the city of Davis, California, where the residents demanded a complete replacement of these high color temperature LED street lights.

Can communities have more efficient lighting without causing health and safety problems?

Light is composed of light of different colors (red, blue and green) and some LED streetlights have a relatively high portion of blue light, which can disrupt people's circadian rhythms. flakepardigm/flickr, CC BY-SA

Two problems with LED street lighting

An incandescent bulb has a color temperature of 2400K, which means it contains far less blue and far more yellow and red wavelengths. Before electric light, we burned wood and candles at night; this artificial light has a CT of about 1800K, quite yellow/red and almost no blue. What we have now is very different.

The new "white" LED street lighting which is rapidly being retrofitted in cities throughout the country has two problems, according to the AMA. The first is discomfort and glare. Because LED light is so concentrated and has high blue content, it can cause severe glare, resulting in pupillary constriction in the eyes. Blue light scatters more in the human eye than the longer wavelengths of yellow and red, and sufficient levels can damage the retina. This can cause problems seeing clearly for safe driving or walking at night.

You can sense this easily if you look directly into one of the control lights on your new washing machine or other appliance: it is very difficult to do because it hurts. Street lighting can have this same effect, especially if its blue content is high and there is not appropriate shielding.

The other issue addressed by the AMA statement is the impact on human circadian rhythmicity.

Color temperature reliably predicts spectral content of light – that is, how much of each wavelength is present. It's designed specifically for light that comes off the tungsten filament of an incandescent bulb.

However, the CT rating does not reliably measure color from fluorescent and LED lights.

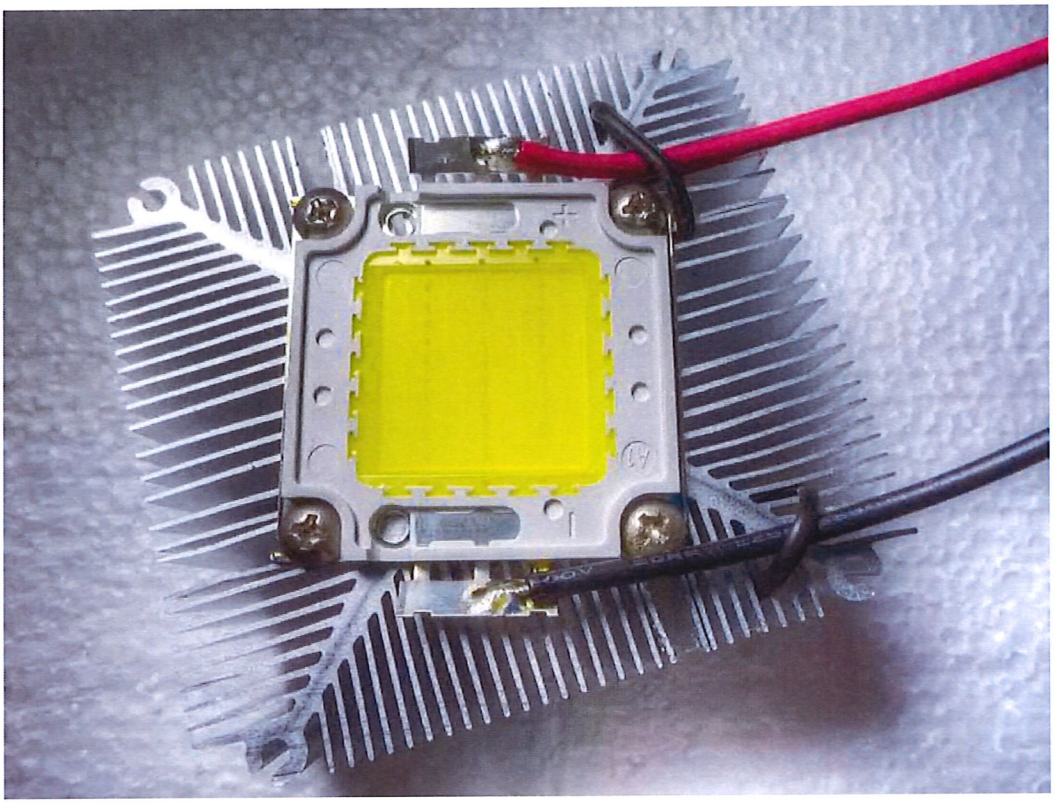
Another system for measuring light color for these sources is called correlated color temperature (CCT). It adjusts the spectral content of the light source to the color sensitivity of human vision. Using this rating, two different 3000K light sources could have fairly large differences in blue light content.

Therefore, the AMA's recommendation for CCT below 3000K is not quite enough to be sure that blue light is minimized. The actual spectral irradiance of the LED – the relative amounts of each of the colors produced – should be considered, as well.

The reason lighting matters

The AMA policy statement is particularly timely because the new World Atlas of Artificial Night Sky Brightness just appeared last week, and street lighting is an important component of light pollution. According to the AMA statement, one of the considerations of lighting the night is its impact on human health.

In previous articles for The Conversation, I have described how lighting affects our normal circadian physiology, how this could lead to some serious health consequences and most recently how lighting the night affects sleep.



LEDs (the yellow device) produce a highly concentrated light, which makes glare a problem for LED streetlights since it can hamper vision at night. razor512/flickr, CC BY

In the case of white LED light, it is estimated to be five times more effective at suppressing melatonin at night than the high pressure sodium lamps (given the same light output) which have been the mainstay of street lighting for decades. Melatonin suppression is a marker of circadian disruption, which includes disrupted sleep.

Bright electric lighting can also adversely affect wildlife by, for example, disturbing migratory patterns of birds and some aquatic animals which nest on shore.

Street lighting and human health

The AMA has made three recommendations in its new policy statement:

First, the AMA supports a "proper conversion to community based Light Emitting Diode (LED) lighting, which reduces energy consumption and decreases the use of fossil fuels."

Second, the AMA "encourage[s] minimizing and controlling blue-rich environmental lighting by using the lowest emission of blue light possible to reduce glare."

Third, the AMA "encourage[s] the use of 3000K or lower lighting for outdoor installations such as roadways. All LED lighting should be properly shielded to minimize glare and detrimental human and environmental effects, and consideration should be given to utilize the ability of LED lighting to be dimmed for off-peak time periods."

There is almost never a completely satisfactory solution to a complex problem. We must have lighting at night, not only in our homes and businesses, but also outdoors on our streets. The need for energy efficiency is serious, but so too is minimizing human risk from bad lighting, both due to glare and to circadian disruption. LED technology can optimize both when properly designed.

Environmental health LEDs Lighting LED lighting